Numerical Analysis of Leaf Spring for Automobile Applications

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Abstract

The automobile firm has shown greater interest for replacement of conventional steel leaf spring with that of 65SI7 steel leaf spring, as the material has high strength to weight ratio and better corrosion resistance. The main objective of this work is to compare the load enhancing capacity, and weight savings of 65SI7 steel leaf spring with respect to conventional steel leaf spring. In this work, the numerical analysis of 65SI7 steel leaf spring using static analysis conditions. By using this developed model to predict the stress and deformation of leaf spring is performed using analysis software. Besides, the finite element model has been developed by using the numerical simulation using ANSYS software.

Keywords: Leaf Spring, Numerical Analysis, Stress and Deformation

I. INTRODUCTION

Leaf springs are suspension system used in vehicles. They were originally called carriage or laminated springs. It is made of an arc shape slender piece of steel that are stacked with the same material in smaller sizes and bolted together creating a reinforced bow like item. A leaf spring works on the principle of bending. When load is applied at the ends bending occurs. Naturally the structure opposes bending. This results in a reaction force which opposes the load applied. Thereby we get the spring property of the leaf spring.

The general reason for leaf spring is to offer help to a vehicle and to give a smoother ride retaining any knocks or stuns from potholes out and about are track. Leaf springs are additionally used to find the hub and control the tallness at which the vehicle rides and helps keep the tires adjusted out and about. Leaf springs are an essential type of suspension comprised of layers of steel of shifting sizes sandwiched one upon the other. Most leaf spring arrangements are framed into a circular shape using spring steel which has properties that permit it to flex as pressing factor is added at one or the flip side, however then getting back to its unique situation through damping measure. The steel is for the most part cut into rectangular areas and afterward once held together by metal clasps at one or the flip side or a huge bolt through the focal point of the leafs. It is then mounted to the pivot of the vehicle utilizing enormous U bolts the upsides of leaf spring are that because of sheer measure of metal layered together, leaf springs offer a lot of help between the wheel, axles and the vehicles skeleton. They can take colossal vertical burdens being applied to them because of their very close construction, subsequently why hard core enterprises actually use them. Vertical stacking is additionally disseminated all through the length of the leaf spring as opposed to intensely through a little spring and damper. Hardly any drawbacks of leaf springs are that they permit not very many headings of movements and are simply intended to move vertically, while a spring and damper blend can be controlled into a lot bigger scope of movement. Leaf springs are immovably cinched together and rushed to the suspension just as clasp to the pivot, along these lines giving little extension for some other course of movement. Suspension set up. The work introduced in this paper is principally worried about examination of leaf spring by utilizing limited component strategy (FEM). The determinations utilized for planning the leaf spring have a place with two kinds – Mild steel and 65SI7. The presentation of composites helps in planning a superior suspension framework with better ride quality in the event that it tends to be accomplished absent a lot of expansion in cost and diminishing in quality and dependability. The relationship of the particular strain energy can be communicated as it is notable that springs, are intended to ingest and store energy and afterward discharge it gradually. Capacity to store and assimilate more measure of strain energy guarantees the agreeable suspension framework. It tends to be effectively seen that material having lower modulus and thickness will have a more prominent explicit strain energy limit. The presentation of composite materials made it conceivable to lessen the heaviness of the leaf spring without decrease of burden conveying limit and solidness because of more versatile strain energy stockpiling limit and high solidarity to weight proportion.

Abdul Rahim et al. [1] worked on developing a composite based elliptic spring for automotive applications. They consider light and heavy trucks with steel elliptic spring for analysis of fatigue performance and weight reduction by using ANSYS software.

They concluded that composite elliptical springs have superior fatigue performance than steel. Also, they have compared the finite element result of fatigue life and weight reduction with existing analytical and experimental result.

Anandkumar et al. [2] explored on mono composite leaf spring design. In his work, they consider light vehicle of Maruti Omni's rear suspension system with steel leaf spring for analysis of strength and weight reduction ratio by using ANSYS software. The goal is to compare strength and weight savings of composite leaf spring with that of steel leaf spring. Also they have compared the finite element result of strength and weight reduction ratio with existing analytical and experimental result. After that using this result they have return steel leaf spring by composite material of Glass fiber-7781 and epoxy resin and analyze it with same loading condition. After they concluded that the results of the analytical and experimental analysis are almost same and they use the composite material instead of steel, they have to change dimensions. Here they have changed the thickness rom 5 mm to 12 mm. The weight reduction is achieved 88%. The composite material is having chipping resistance problem, but it may avoid by using carbon fibers.

Ashish et al [3] presented work on design & assessment of leaf spring. The main objective of this work is to compare the load carrying capacity, stresses and weight saving of composite leaf spring with that of steel leaf spring. Here the multi leaf spring consist of three full length leaves in which one is with eyed ends used by a light commercial vehicle. For analysis of leaf spring Tata ace ex vehicle taken as prototype. This work deals with replacement of conventional steel leaf spring of a light commercial vehicle with composite leaves spring using E-glass/Epoxy. Dimensions of the composite leaf spring are to be taken as same dimension of the conventional leaf spring. The Theoretical and CAE results are compared for validation. From results it is proved that the bending stresses are decreased by 25.07% in composite leaf spring means less stress induced with same load carrying condition. The conventional multi leaf spring weights about 10.27kg where the E-glass/Epoxy multi leaf spring weighs only 3.26 kg. Thus the weight reduction of 67.88% is achieved by using composite material rather than using steel material.

Dev et al [4] had done Design and analysis of composite leaf spring. ANSYS has been used to conduct the analysis. Static structural tool has been used of ANSYS. A three layer composite leaf spring with full length leave. E-Glass/epoxy composite material has been used. Conventional steel leaf spring results have been compared with the results obtained for composite leaf spring. E glass/epoxy material is better in strength and lighter in weight as contrast with conventional steel leaf spring. A wide amount of study has been conducted in his paper to investigate the design and analysis of leaf spring and leaf spring fatigue life. Results demonstrate that composite leaf spring deflection for a particular load is less compared to conventional leaf spring. Stress generated in the E-Glass/Epoxy leaf spring is lower than steel leaf spring. Composite (E-Glass/Epoxy) leaf spring directional deformation is low compared to steel leaf spring. Composite leaf spring is lighter in weight compared to conventional steel leaf.

Dhoshi et al [5] have worked on analysis and method. In this paper, they consider tractor trailer with seventeen-leaf steel spring for analysis of stress and deflection by using ANSYS software. The objective is to compare the load carrying capacity, stiffness and weight savings of composite leaf spring with that of steel leaf spring. Also they have compared the finite element result of stresses and deflection with existing analytical and experimental result and using this result they replace steel leaf spring by composite material of E-glass/epoxy and analyse it with same loading condition for stresses and deflection. The dimensions and the number of leaves for both steel leaf spring and composite leaf springs are considered to be the same. They consider design constraints were stresses and deflections. They concluded that, the composite leaf spring have much lower stress and deflection than that of existing steel leaf spring. Also they concluded that weight of composite leaf spring was nearly reduced up to 80%compare to steel leaf spring.

II. NUMERICAL WORK

Mild steel is selected for the present investigation. The dimensions of the selected material are found using Vernier callipers, screw gauge. According to the dimensions of the leaf spring is modelled using Creo Software. The modelled mild steel is as shown in Figure 1. During this analysis three different materials are used. The dimension of work pieces having 100 mm height and 1800 mm Diameter.

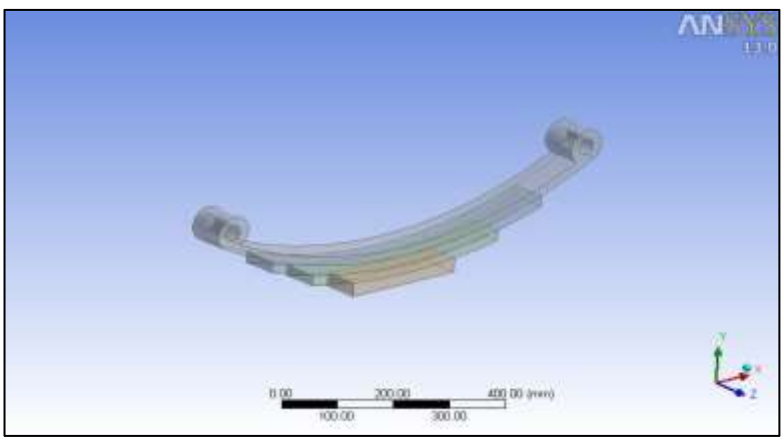


Fig. 1: 3D Leaf Spring

The tetrahedron mesh was used to mesh the leaf spring. The below said parameters are used for meshing. Number of Nodes: 32450. Number of Elements: 14234. A model of connecting wire is used for analysis in ANSYS Workbench. Analysis is done with the pressure of 3.15 MPa load applied at the leaf spring of the connecting wire and fixed at the crank end of the connecting wire.

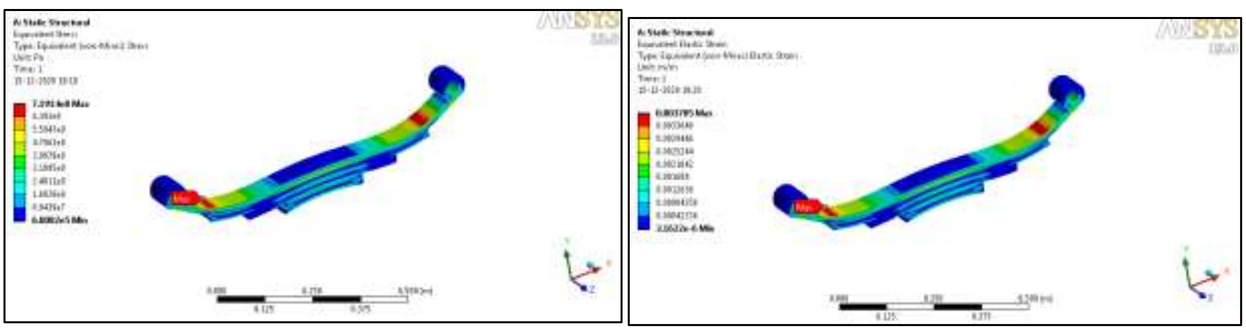
(A. Fixed support) (B. LOAD)

Fig. 2: Loading conditions of specimen

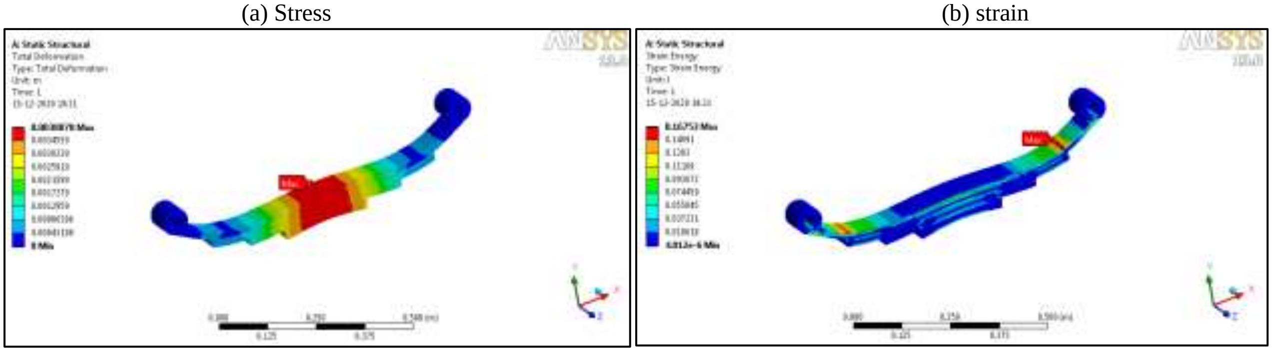
III. RESULTS AND DISCUSSION

For the finite element analysis, 1000 KN of load is used as shown in Figure 2. The analysis is carried out using Creo and ANSYS work bench software. The pressure is applied at the small end of connecting wire keeping big end fixed. The maximum and minimum von-misses stress, strain, and shear stress, are noted from the ANSYS Work bench.

A. 65SI7 STEEL- LOAD AT 200 KN



(a) Stress (b) strain

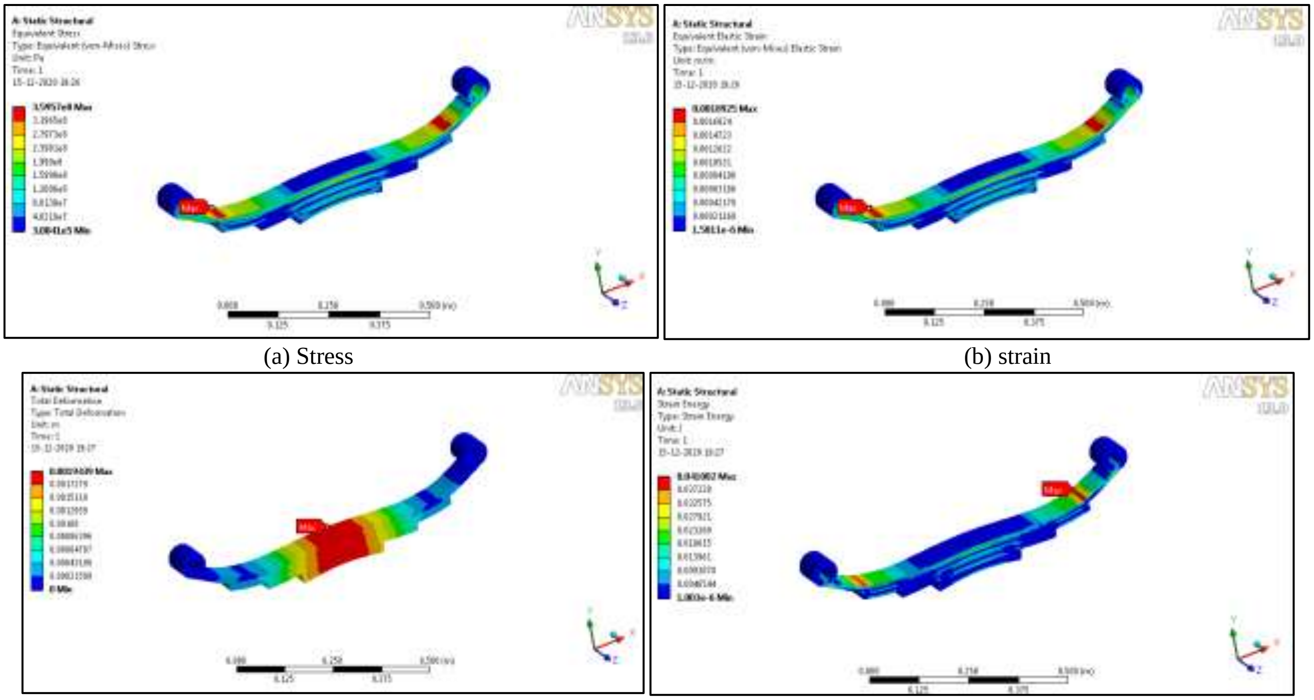


(c) Deformation (d) Strain energy

Fig. 3: 200 KN Load-65SI7 Steel Results

Figure 3 shows distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 7.1914 X 10^8 Pa. Maximum strain value 0.003785 Maximum deformation 0.0038878 mm and strain energy is 0.16753 J. Design is not safe. Stress value of the result is higher than Yield stress value of the stainless steel (7.1914 X 10^8 Pa. > 1.9 X 10^8 Pa).

B. LOAD AT 100 KN AT 65SI7 STEEL



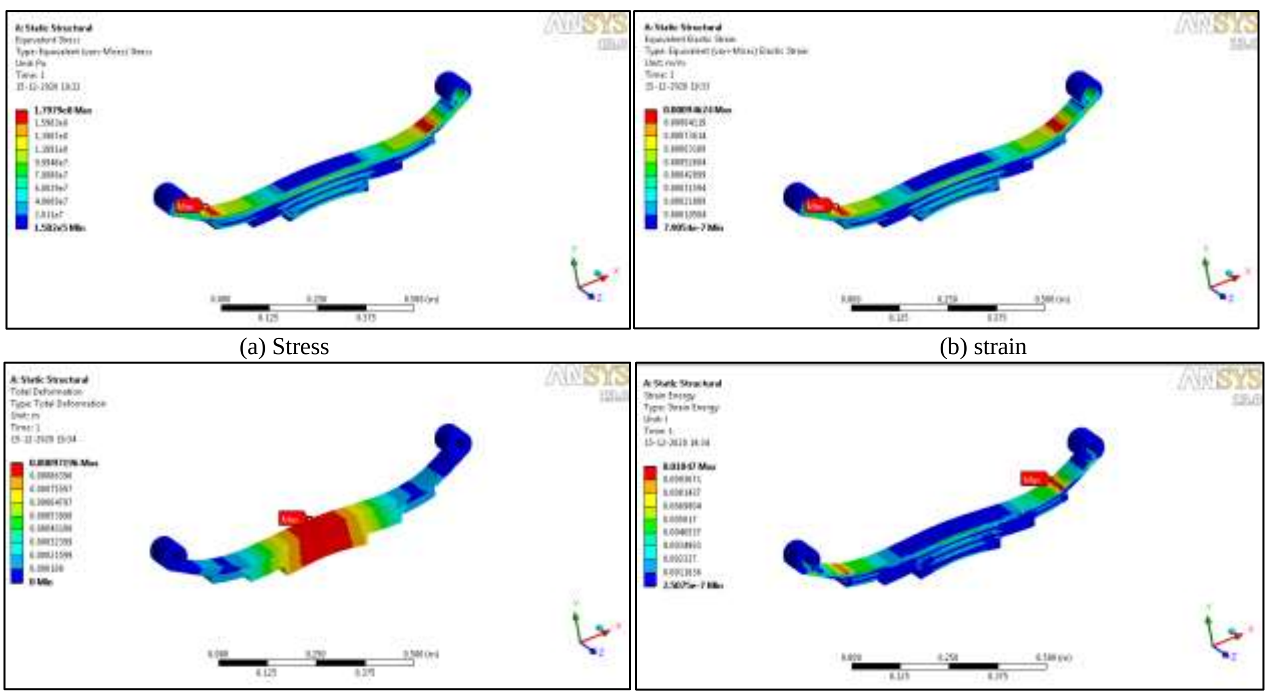
(a) Stress (b) strain

(c) Deformation (d) Strain energy

Fig. 4: 100 KN Load-65SI7 Steel Results

Figure 4 shows main results of computation: distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 3.5957 X 10^8 Pa. Maximum strain value 0.0018925 Maximum deformation 0.0019439 mm and strain energy is 0.041882 J. Design is not safe. Stress value of the result is higher than Yield stress value of the stainless steel (3.5957 X 10^8 Pa. > 1.9 X 10^8 Pa).

C. LOAD AT 50 KN AT 65SI7 STEEL



(a) Stress (b) strain

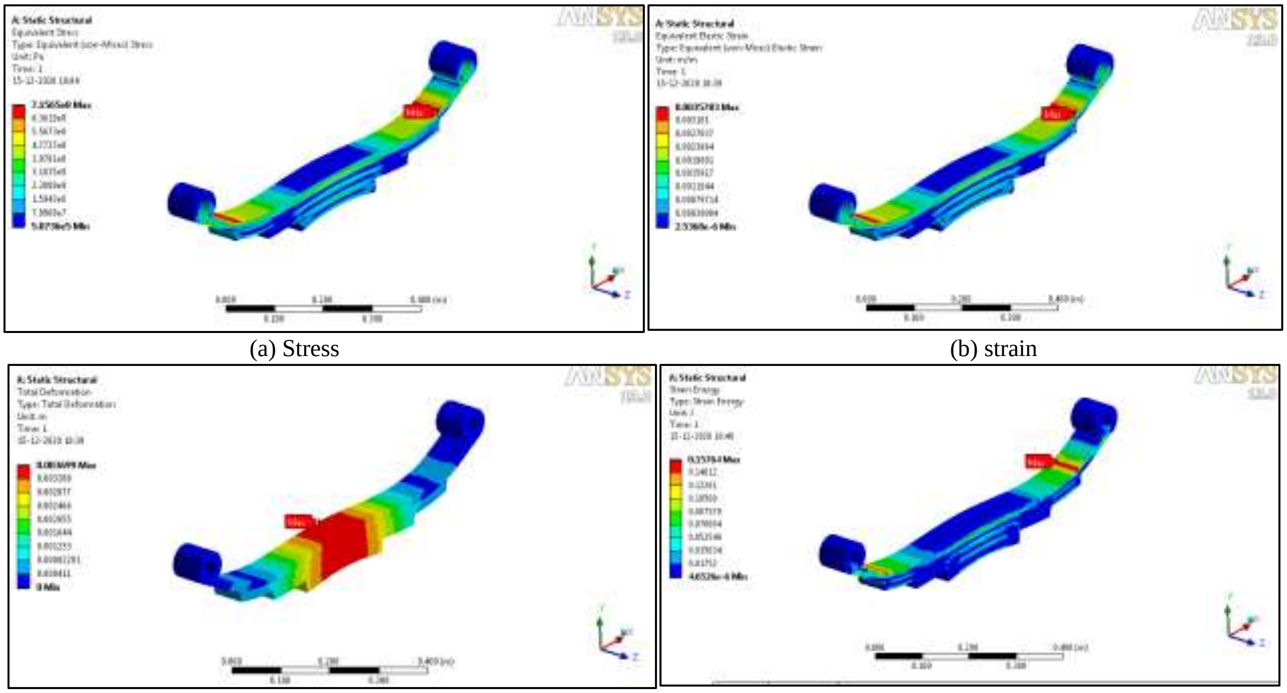
(c) Deformation (d) Strain energy

Fig. 5: 50 KN Load-65SI7 Steel Results

Figure 5 shows main results of computation: distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 1.7979 X 10^8 Pa. Maximum strain value

0.00094624 Maximum deformation 0.00097196 mm and strain energy is 0.01047 J. Design is safe. Design safe Stress value is less than Yield stress value 1.7979X10^8 Pa < 1.9 X 10^8 Pa

D. LOAD AT 200 KN AT MILD STEEL



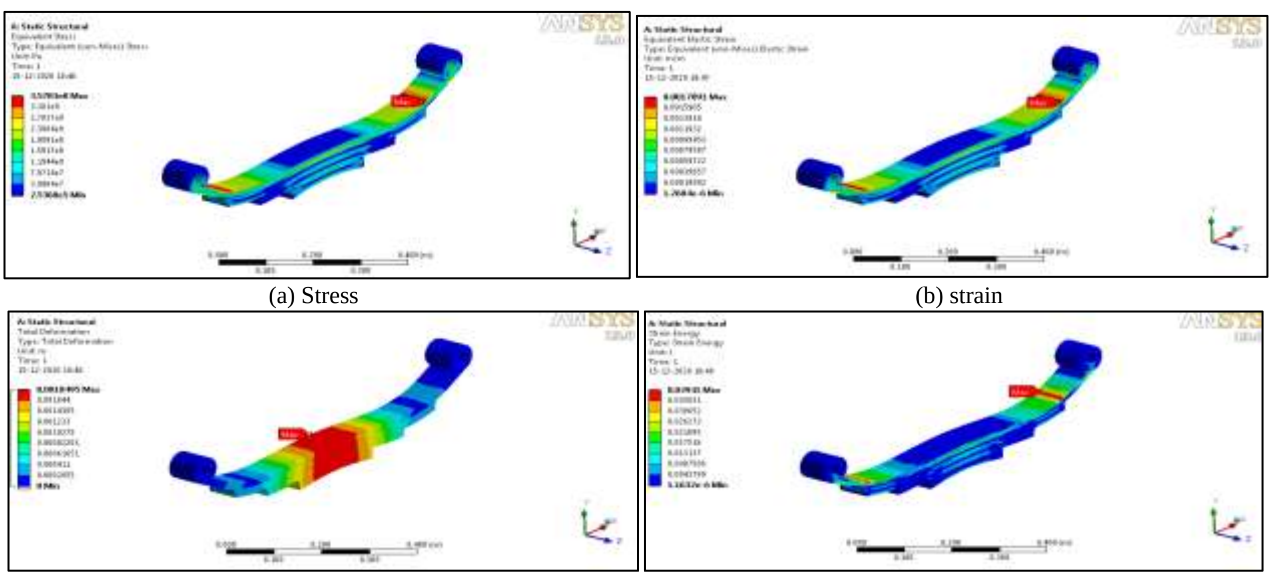
(a) Stress (b) strain

(c) Deformation (d) Strain energy

Fig. 6: 200 KN Load Mild Steel Results

Figure 6 shows main results of computation: distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 7.1565 X 10^8 Pa. Maximum strain value 0.0035783 Maximum deformation 0.003699 mm and strain energy is 0.15764 J. Design not is safe. Design Not safe Stress value is higher than Yield stress value 7.1565 X10^8 Pa > 2.5 X 10^8 Pa

E. LOAD AT 100 KN AT MILD STEEL



(a) Stress (b) strain

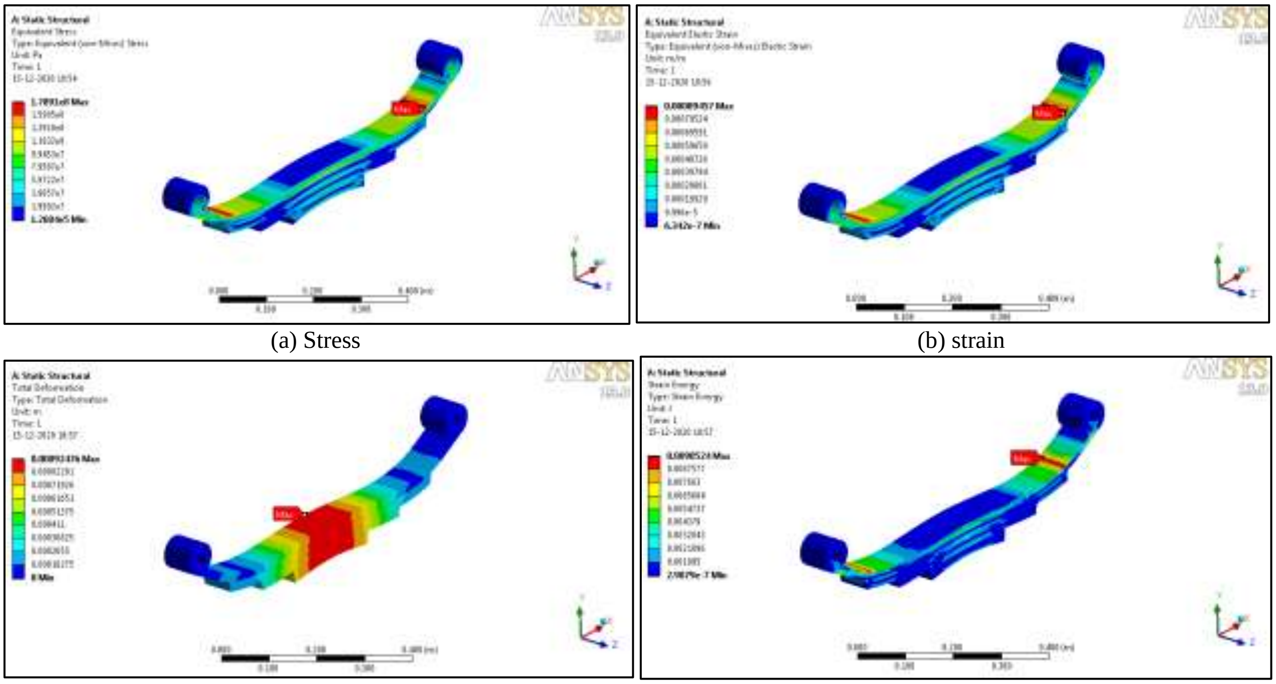
(c) Deformation (d) Strain energy

Fig. 7: 100 KN Load Mild Steel Results

Figure 7 shows main results of computation: distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 3.5783 X 10^8 Pa. Maximum strain value

0.0017891 Maximum deformation 0.0018495 mm and strain energy is 0.03941 J. Design not is safe. Design is not safe. Stress value is higher than Yield stress value 3.5783 X10^8 Pa > 1.9 X 10^8 Pa

F. LOAD AT 50 KN AT MILD STEEL



(a) Stress (b) strain

(c) Deformation (d) Strain energy

Fig. 8: 50 KN Load Mild Steel Results

Figure 8 shows main results of computation: distribution of resultant equivalent stress, equivalent strain, deformation and strain energy in the elements of leaf spring. It may be seen that the maximum stress value 1.7891 X 10^8 Pa. Maximum strain value 0.00089457 Maximum deformation 0.00092476 mm and strain energy is 0.0098524 J. Design is safe. Design safe Stress value is less than Yield stress value 1.7891X10^8 Pa < 1.9 X 10^8 Pa

Table – 1
Comparison of numerical analysis Values

LOAD	*6S5I7*	*REMARKS*	*MILD STEEL*	*REMARKS*
200 KN	*7.1914 X10^8 Pa*	*Design Not Safe*	*7.1565 X10^8 Pa*	*Design Not Safe*
150 KN	*3.5957 X10^8 Pa*	*Design Not Safe*	*3.5783 X10^8 Pa*	*Design Not Safe*
100 KN	*1.7979X10^8 Pa*	*Design Safe*	*1.7891X10^8 Pa*	*Design Safe*

From table 1, In this case it might be expressed that the leaf spring on its structure which may causes stress. To get a better result (stress, strain, deformation) the proposed model is in steel material, Appling the static force by different directional force. Results of static structural analysis of the leaf spring applied under the static structural force. By this result mild steel leaf spring is best one for commercial application by cause of stress value under various force condition.

IV. CONCLUSION

From the static analysis results, we see that the von- mises stress in the mild steel is 1.4313 x 10 ^{8} Pa and the von- mises stress in 65SI7 is 1.438 x 10 ^{8} Pa. Mild steel leaf spring reduces the weight by nearly 74%. From the fatigue analysis results, the usage factor of 65SI7 is very much less compared to mild steel. Hence it is advantageous to replace mild steel leaf spring with 65SI7.

REFERENCES

[1] Abdul Rahim Abu Talib, Aidy Ali, G. Goudah "Developing a composite based elliptic spring for automotive applications", Materials and Design, 31, 2010, 475–484.

[2] Anandkumar A. Satpute, Prof. S. S. Chavan, "Mono Composite Leaf Spring –Design and Testing", Indian Journal of Applied Research, Volume 3, Issue 7, 2013.

[3] Ashish V. Amrute, et al., and (2013) Design and Assessment of Multi leaf spring International Journal of Research in Aeronautical and Mechanical Engineering Issn (Online): 2321-3051 Vol.1 Issue.7

[4] Dev dutt Dwivedi, V.K.Jain, (2016) "Design and Analysis of Automobile leaf spring"ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697, VOLUME-3, ISSUE-1.

[5] N. P. Dhoshi, Prof. N. K. Ingole, Prof. U. D. Gulhane, "Analysis and modification of leaf spring of tractor trailer using analytical and finite element method", International Journal of Modern Engineering Research, Vol.1, Issue.2, pp 719-722.